

WHAT IS CLAIMED IS:

1. An internal combustion engine that is driven to output a required torque to an output shaft, said internal combustion engine comprising:

a compression mechanism that compresses an air-fuel mixture containing a fuel and the air taken into said internal combustion engine;

a compression ratio changeover mechanism that changes over a compression ratio of the air-fuel mixture compressed by said compression mechanism;

a motor transmits torque to and from said output shaft of said internal combustion engine;

a torque demand detection module that detects a torque demand, which is required to said output shaft of said internal combustion engine;

a specification module that compares the detected torque demand with a threshold torque, which is set in advance for changeover of setting of the compression ratio in said internal combustion engine, and distributes the torque demand into a first torque value to be transmitted between said motor and said output shaft and a second torque value to be output from said internal combustion engine based on a result of the comparison, said specification module specifying a desired setting of the compression ratio based on the result of the comparison;

a motor control module that controls said motor to regulate torque transmission between said motor and said output shaft

according to the first torque value; and

a driving module that controls said compression ratio
changeover mechanism to change over setting of the compression
ratio in said internal combustion engine according to the
5 specification of the desired setting of the compression ratio.

2. An internal combustion engine in accordance with claim
1, wherein said specification module distributes the torque demand
in such a manner as to reduce a frequent change of the torque
10 division to be output from said internal combustion engine across
the threshold torque, in response to a variation in detected torque
demand.

3. An internal combustion engine in accordance with either
15 one of claims 1 and 2, wherein said specification module comprises
a control area storage sub-module that stores a control area to
specify setting of the compression ratio in said internal
combustion engine and state of the first torque value,
corresponding to at least the torque demand required to said output
20 shaft, and

said driving module comprises a driving instruction
sub-module that gives at least an instruction of changing over
the compression ratio to said compression ratio changeover
mechanism and an instruction of torque transmission to said motor
25 control module, according to the specification of the control area
stored in said control area storage sub-module.

4. An internal combustion engine in accordance with claim 3, wherein said control area storage sub-module stores multiple control areas, which at least include:

a first control area to specify setting of a predetermined compression ratio in said internal combustion engine and selection of no torque as the first torque value, corresponding to a range of lower torque demand than the threshold torque, and

a second control area to specify setting of the predetermined compression ratio in said internal combustion engine and selection of the first torque value, corresponding to a range of higher torque demand than the threshold torque, and

said driving instruction sub-module gives the instruction of changing over the compression ratio to said compression ratio changeover mechanism and the instruction of torque transmission to said motor control module, according to the specification of the first control area or the specification of the second control area.

5. An internal combustion engine in accordance with claim 4, said internal combustion engine further comprising:

an accumulator module that accumulates electric power, which is to be supplied to said motor; and

a power accumulation measurement module that measures an amount of power accumulation in said accumulator module,

wherein said control area storage sub-module stores a third control area to specify setting of a lower compression ratio than the predetermined compression ratio in said internal combustion

engine, corresponding to a range of higher torque demand than the torque demand range of the second control area, and

when the observed amount of power accumulation is not greater than a preset threshold value, said driving instruction sub-module
5 gives the instruction of changeover of the compression ratio and the instruction of torque transmission according to the specification of the third control area, in response to the detected torque demand even belonging to the second control area.

10 6. An internal combustion engine in accordance with claim 2, wherein said driving module comprises:

a time counting sub-module that counts elapse of a preset time after the detected torque demand exceeds the threshold torque; and

15 a control sub-module that controls said motor control module to output an increased torque from said motor to said output shaft until the torque demand exceeding the threshold torque continues for the preset time, said control sub-module, when the torque demand exceeding the threshold torque continues for the preset
20 time, changing over the setting of the compression ratio in said internal combustion engine to increase the output torque of said internal combustion engine, while controlling said motor control module to decrease the output torque from said motor to said output shaft

25 7. An internal combustion engine in accordance with claim 6, said internal combustion engine further comprising:

an accumulator module that accumulates electric power, which is to be supplied to said motor; and

a power accumulation measurement module that measures an amount of power accumulation in said accumulator module,

5 wherein said driving module decreases the output torque from said motor to said output shaft before elapse of the preset time, when the observed amount of power accumulation is not greater than a preset threshold value.

10 8. An internal combustion engine with a variable compression ratio, said internal combustion engine comprising:

a compression mechanism that compresses an air-fuel mixture containing a fuel and the air taken into said internal combustion engine;

15 a compression ratio changeover mechanism that changes over a compression ratio of the air-fuel mixture compressed by said compression mechanism;

a motor that transmits torque to and from an output shaft of said internal combustion engine; and

20 a motor control module that controls said motor in the course of changeover of the compression ratio set in said internal combustion engine by said compression ratio changeover mechanism and thereby reduces a variation in output torque of said internal combustion engine to be not greater than a predetermined level.

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9. An internal combustion engine in accordance with claim 8, said internal combustion engine further comprising:

an internal combustion engine control module that controls a driving state of said internal combustion engine with setting of a control amount unchanged in the course of the changeover of the compression ratio, wherein the setting of the control amount
5 is fixed to a specific control amount corresponding to the higher compression ratio between a previous compression ratio before the changeover and a new compression ratio after the changeover.

10. An internal combustion engine in accordance with claim
10 9, wherein said internal combustion engine control module, while the setting of the compression ratio in said internal combustion engine is changed over from a high compression ratio to a low compression ratio, controls the driving state of said internal combustion engine with the control amount kept to a specific
15 control amount corresponding to the high compression ratio, and

said motor control module regulates an output torque from said motor to said output shaft and thereby reduces the variation in output torque of said internal combustion engine, while the setting of the compression ratio in said internal combustion engine
20 is changed over from the high compression ratio to the low compression ratio.

11. A control method of an internal combustion engine, which includes a motor that transmits torque to and from an output shaft
25 of said internal combustion engine and a compression ratio changeover mechanism that changes over setting of a compression ratio of an air-fuel mixture in said internal combustion engine,

said control method comprising the steps of:

detecting a torque demand, which is required to said output shaft of said internal combustion engine;

comparing the detected torque demand with a threshold torque,

5 which is set in advance for changeover of setting of the compression ratio in said internal combustion engine;

distributing the torque demand into a first torque value to be transmitted between said motor and said output shaft and a second torque value to be output from said internal combustion engine based on a result of the comparison;

10 regulating the torque transmission between said motor and said output shaft according to the first torque value;

specifying a desired setting of the compression ratio based on the result of the comparison; and

15 controlling said compression ratio changeover mechanism to change over setting of the compression ratio in said internal combustion engine according to the specification of the desired setting of the compression ratio.

20 12. A control method in accordance with claim 11, said distributing step distributes the torque demand in such a manner as to reduce a frequent change of the torque division to be output from said internal combustion engine across the preset threshold torque, in response to a variation in detected torque demand.

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13. A control method in accordance with either one of claims 11 and 12, said control method further comprising the steps of:

storing a control area to specify setting of the compression ratio in said internal combustion engine and state of the first torque value, corresponding to at least the torque demand required to said output shaft; and

5 giving an instruction to change over the compression ratio and control said motor according to the specification of the control area.

14. A control method in accordance with claim 13, wherein
10 said storing step stores multiple control areas, which at least include:

a first control area to specify setting of a predetermined compression ratio in said internal combustion engine and selection of no torque as the first torque value, corresponding to a range
15 of lower torque demand than the threshold torque, and

a second control area to specify setting of the predetermined compression ratio in said internal combustion engine and selection of the first torque value, corresponding to a range of higher torque demand than the threshold torque, and

20 said instruction-giving step gives an instruction to change over the compression ratio and control said motor according to the specification of the first control area or the specification of the second control area.

25 15. A control method in accordance with claim 14, said control method further comprising the steps of:

measuring an amount of power accumulation in an accumulator

module, which supplies electric power to said motor;

storing a third control area to specify setting of a lower compression ratio than the predetermined compression ratio in said internal combustion engine, corresponding to a range of higher torque demand than the torque demand range of the second control area; and

when the observed amount of power accumulation is not greater than a preset threshold value, giving an instruction to change over the compression ratio and control said motor according to the specification of the third control area, in response to the detected torque demand even belonging to the second control area.

16. A control method in accordance with claim 11, said control method further comprising the steps of:

counting elapse of a preset time after the detected torque demand exceeds the threshold torque;

controlling said motor to output an increased torque from said motor to said output shaft until the torque demand exceeding the threshold torque continues for the preset time; and

when the torque demand exceeding the threshold torque continues for the preset time, changing over the setting of the compression ratio in said internal combustion engine to increase the output torque of said internal combustion engine, while controlling said motor to decrease the output torque from said motor to said output shaft.

17. A control method of an internal combustion engine, which

includes a motor that transmits torque to and from an output shaft of said internal combustion engine and a compression ratio changeover mechanism that changes over setting of a compression ratio of an air-fuel mixture in said internal combustion engine,

5 said control method comprising the step of:

controlling said motor in the course of changeover of the compression ratio set in said internal combustion engine by said compression ratio changeover mechanism and thereby reducing a variation in output torque of said internal combustion engine to
10 be not greater than a predetermined level.